Journal of Forensic and Legal Medicine 22 (2014) 150–153

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/locate/jflm

Original communication

Sex determination using mandibular anthropometric parameters in subadult Iranian samples

Mitra Akhlaghi, MD Associate Professor, Member of Research Center [a,b], Zahra Khalighi, MD Assistant Professor [c,*], Shayesteh Vasigh, MD Assistant [a], Vahid Yousefinejad, MD Specialist in Forensic Medicine [a]

[a] Forensic Medicine Department, Tehran University of Medical Sciences, Tehran, Iran
[b] Research Center of Legal Medicine Organization of Iran, Tehran, Iran
[c] Internal Medicine Department, Ilam University of Medical Sciences, Ilam, Iran

ARTICLE INFO

Article history:
Received 26 November 2012
Received in revised form
25 October 2013
Accepted 7 December 2013
Available online 18 December 2013

Keywords:
Mandible
Anthropometric parameters
Forensic identification
Sex determination
Subadult

ABSTRACT

Introduction: Sex determination is the first step in the identification of corpses and skeletal remains. The mandible is the largest and strongest bone of the face and has high durability. It is known that skeletal features vary by population, thus the need to establish population-specific standards. In this study, for the first time, we investigated mandibular anthropometric parameters for sex determination in subadult Iranian cadavers.

Methods: Eight mandibular anthropometric parameters were measured in 45 Iranian cadavers below the age of 20 (23 males and 22 females corpses), and the relationships of these variables with gender were determined. Collected data were analyzed using descriptive analysis, ROC curve, cross tabulation and discriminant analysis in SPSS 13.

Results: No significant statistical difference was seen in the mandibular anthropometric values between the two genders in samples below the age of 12. In the 12–19 age group, accuracy of symphysial height and bigonial breadth in differentiation of gender was 69% and 86.2% respectively.

Conclusion: Although mandibular anthropometric parameters are not helpful in sex determination below the age of 12, if for some reasons such as explosions, air disasters and other accidents, only the mandible is available, symphysial height and mandibular bigonial breadth could be used to determine the gender with high accuracy.

1. Introduction

Skeletal remains from air disasters, natural disasters, explosions, mutilations, etc. are sent to forensic medicine departments.[1,2] The known problem in forensic medicine is identification and sex determination which is in need of knowledge and expertise in anatomy, radiology, archeology, dentistry and other pertinent fields.[3]

Nearly all parts of the human skeleton are studied for sex determination and the accuracy of sex determination by different bones is investigated in some populations.[4] Anthropometric parameters of some bones such as tibia, clavicle and radius in sex determination have been evaluated in previous studies in Iran.[5–7]

Morphological, metric and molecular studies are also available.[1] Morphological criteria are observable and of course, need enough experience, but metric criteria are repeatable and are based on bone measurements which are applicable to bone fragments.[8] Measurement techniques and data analysis can help us determine the identity with more accuracy.[9] In addition, craniometrical measurements play a role in specific scenarios of sex determination.[10]

Mandibular growth begins in the fifth week of gestation from the ventral mesenchyme. At birth, mandible is in two halves which fuse anteriorly via a fibrous tissue that ossifies in the first year of life.[11]

Mandible is the largest and strongest bone of the face, therefore, in comparison to other facial bones, remains for a longer time and has a slower degradation.[11] Several studies have examined mandibular anthropometric measurements in different races for gender identification and mandibular accuracy for sex determination is reported to be 80.2–92% in adults.[2–4,8–13] Some researchers

* Corresponding author. Tape Str., Mostafa Khomeini Hospital, Internal Medicine Department, Ilam University of Medical Sciences, Ilam, Iran. Tel.: +98 841 3338265.
E-mail address: zahrakhalighi@yahoo.com (Z. Khalighi).

1752-928X/$ – see front matter
http://dx.doi.org/10.1016/j.jflm.2013.12.006

have used the mandible in age estimation.[14] and others have studied its odontometrics in sex determination in subadults,[15] but knowledge of mandibular parameters in gender determination in subadult population is scarce.[16] To date, sex determination of subadult skeletal remains with satisfactory accuracy remains an important issue in archaeological research and forensic practice.[16]

As skeletal features vary by population, each population requires its own standards for assessment,[12,13] given the fact that few studies investigated the mandible to determine the sex in subadult samples.[17,18]

In this study, mandibular anthropometric measurements for gender determination were studied in Iranian cadavers younger than the age of 20.

2. Materials and methods

The study population of this cross-sectional investigation consisted of Iranian cadavers younger than the age of 20, which were brought to Tehran autopsy hall of Legal Medicine Organization from 2011 to 2012. The study was carried out on 45 cadavers. Nine male and 7 female cadavers were under the age of 12. Fourteen male and 15 female cadavers were in the 12–19 years old age group.

Exclusion criteria were unidentified cadavers, refusal to provide a written consent by the first-degree relatives, severely burned bodies, traumatic mandibular fractures and skeletal anomalies.

After obtaining written consent from the first-degree relatives of the deceased and according to the inclusion and exclusion criteria in cadavers which needed autopsy to determine the cause of death, neck dissection was performed with a Y incision expanded to the face. Without removal of the bone, mandibular anthropometric measurements including symphysial height, mental foramen to basal border distance, mental foramen to alveolar border distance, mental angle, minimum ramus breadth, gonion (mandibular angle), mandibular body length and bigonial breadth were recorded (Fig. 1). All measurements were performed on the right side and the face was reconstructed after dissection.

Measurements were done using a caliper with an accuracy of 0.1 mm and angles were measured by a goniometer. In order to determine the mandibular body length, distance between gonion and gnation was measured by placing a rod below the mandible between these two points.

Descriptive statistical analysis (frequency-descriptive), ROC curve analysis, cross tabulation and discriminant analysis were used to analyze the data in SPSS 13.

3. Results

In cadavers younger than 12 years old, the mean age was 5.82 ± 4.03 yrs and in the 12–19 years old age group, the mean age was 16.38 ± 2.24 yrs.

Mandibular anthropometric measurements were not significantly different between the two genders, in cadavers below the age of 12 ($p > 0.05$). In the 12–19 years age group, symphysial height and bigonial breadth were significantly different between males and females. Sex differentiation accuracy of symphysial height and bigonial breadth was 69.0% ($p = 0.034$) and 86.2% ($p = 0.001$) respectively. Table 1 presents mandibular anthropometric measurements of the studied samples.

ROC curve was used for calculation of sensitivity and specificity of symphysial height and bigonial breadth for sex determination in 12–19 years age group. Based on symphysial height measurements, with the 3.25 cm cut point, calculated sensitivity and specificity for gender determination was 80% and 57% respectively. For bigonial breadth with a 7.85 cm cut point, calculated sensitivity and specificity for gender determination was 74% and 100% respectively.

Using Fisher's linear discriminant function test, the following formula was obtained which could predict gender with 86.2% accuracy:

$$A = [(\text{Bigonial breadth(cm)} \times 22.163)] - 84.027$$

$$B = [(\text{Bigonial breadth(cm)} \times 52.009)] - 106.804$$

If $A > B$, mandible belongs to a female cadaver otherwise it is for a male.

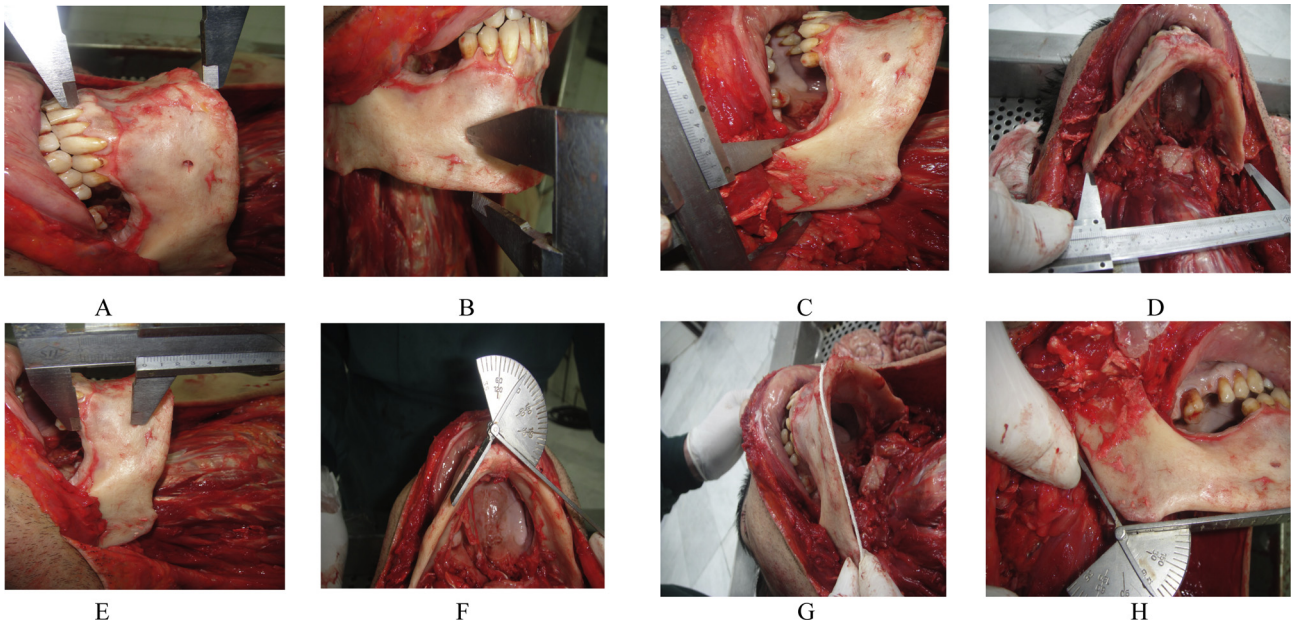

Fig. 1. Technique of measurement of Symphysial height (A), Mental foramen to basal border distance (B), Minimum ramus breadth (C), Bigonial breadth (D), Mental foramen to alveolar border distance (E), Mental angle (F), Body length (G), and Mandibular angle (H).

Table 1
Comparison of mean, standard deviation and *p* value of mandibular anthropometric parameters by sex in the two age groups.

	Lower than 12 years old		12–19 years old	
	Mean	Standard deviation	Mean	Standard deviation
Female				
Symphysial height[a]	2.32	0.33	3.03	0.36
Mental foramen to mandibular basal border distance	1.01	0.24	1.40	0.18
Mental foramen to alveolar border distance	1.20	0.34	1.71	0.23
Minimum ramus	2.29	0.63	3.03	0.40
Bigonial breadth[b]	6.24	1.39	8.52	0.70
Mental angle	89.14	15.7	96.60	9.52
Mandibular angle	97.0	7.92	100.60	12.02
Body length	6.51	1.61	8.45	0.37
Male				
Symphysial height[a]	2.58	0.67	3.39	0.49
Mandible to base	1.09	0.32	1.49	0.25
Mandible to surface	1.19	0.31	1.82	0.31
Minimum ramus	2.60	0.45	3.36	0.47
Bigonial breadth[b]	6.53	1.55	7.49	0.43
Mental angle	88.56	6.41	95.29	9.55
Mandibular angle	101.0	12.01	113.20	7.91
Body length	6.82	1.35	8.70	0.48

[a] $p = 0.034$, accuracy = 69% (in 12–19 years old group).
[b] $p = 0.001$, accuracy = 86.2% (in 12–19 years old group).

4. Discussion

Sex determination of human skeletal remains is an important part and the first step in the anthropologic studies. Previous studies have shown that different populations have different bone characteristics and such differences may affect gender identification.[11,19,20]

Although sex determination of the complete skeleton can be performed quickly and accurately, often times, parts of the skeleton are available in the forensic medicine, thus obtaining maximum information, including sex and bone age, is of utmost importance. Previous studies have shown limitations in sex determination by mandibular parameters in subadults.[16,26]

In this study, mandibular anthropometric measurements were studied for sex determination in Iranian cadavers younger than 20 years of age during the 2011–2012 period. In consistence with the majority of previous studies, most measured variables were greater in males than in females.[3,4,11]

In 2009, Suazo et al. studied 32 mandibles of Brazilian infants less than 1 year old and reported higher measurements in mean of symphysial height, body length and bigonial breadth in males yet not reaching a significant level.[21] This is comparable to our findings in cadavers younger than 12 years old (Table 2), therefore it seems that in early childhood; sex determination could not be easily achieved based on mandibular measurements. Meanwhile, mandibular body length (gnation–gonion) and bigonial breadth in 12–19 years old samples in our study were significantly higher in males than females ($p < 0.05$).

In another study completed in Brazil in 2001 by Loth and Henneberg,[22] 19 mandibles from ages 7 months to 4 years were selected and were evaluated based on the shape and morphological characteristics. One of the studied morphological parameters was the mental shape. The results revealed that the female mandible, contrary to male, has a more circular shape with a gradual curvature from the lateral side toward the anterior. The overall accuracy for gender determination was 81%, being higher in boys compared to girls. In another study, 11 cases with known gender from birth to 7 years of age were selected and dried bones were studied by CT scan where the accuracy reached 82%.[22]

Table 2
Comparison of mandibular anthropometric parameters by sex between our study and Suazo et al. study.

	This study	This study	Suazo et al.[21]
	<12 years old (Mean ± SD)	12–19 years old (Mean ± SD)	<1 year (Mean ± SD)
Female			
Symphysial height	2.32 ± 0.33	3.03 ± 0.36*	1.29 ± 0.26
Bigonial breadth	6.24 ± 1.39	8.52 ± 0.70**	4.91 ± 0.65
Body length	6.51 ± 1.61	8.45 ± 0.37	3.85 ± 0.56
Male			
Symphysial height	2.58 ± 0.67	3.39 ± 0.49*	1.36 ± 0.26
Bigonial breadth	6.53 ± 1.55	7.49 ± 0.43**	5.04 ± 0.68
Body length	6.82 ± 1.35	8.70 ± 0.48	4.01 ± 0.53

*$p = 0.034$.
**$p = 0.001$.
In other figures $p > 0.05$.

In a study composed in England in 2002 by Louise Scheuer,[23] 36 mandibles with known age (age range from 5 months to 4.7 years) and gender, dated back to 250 years ago, from London museums were selected. In two sessions and in two different days, mandibular morphological criteria were evaluated similar to the Loth et al. method.[22] The accuracy was 77.7% in the first session for men and 66.6% for women, and in the second session, it increased to 85.1% for men while decreasing to 44.4% for women. Considering both sessions, the overall accuracy was 64%, which is much less than the Loth and Henneberg study.[22]

In a study conducted in 2007 in Australia by Daniel Franklin, 96 subadult mandibles between 1 and 17 years old in three African American, South African and Asian populations were examined for morphologic parameters. It was shown that in younger ages, mental angle has less prominence and as the age increases, this prominence will be enhanced yet not significant for gender determination, with an overall low accuracy of 55% in men, 65% in women and 59% in the whole population.[16]

In a study completed in 2008 by Suazo et al. in Brazil, 33 skulls of known gender younger than 1 year of age from Savita University (20 boys and 13 girls) were studied. Morphologic evaluation based on symphysial and body characteristics of the mandible was carried out in two sessions. Calculated accuracy in the first and the second session was 57.3% and 63.6% respectively.[24]

As it is shown, morphological criteria yield different accuracies based on racial differences, population age composition, methods and skill of the examiners. Age composition and the relatively small sample size might explain the reported absence of significance in our study for cadavers younger than 12 years old. In contrary to the studies cited above,[16,22–24] which used morphological parameters, we used metrics measurements.

In 2006, a study was conducted in Turkey by Mehmet Ali Malas et al. on 161 fetuses (83 males and 78 females) between the ages of 9 and 40 weeks of gestation. Mention-gonion distance was measured with calipers. Fetuses were divided into four groups based on the gestational age: zero to 12 weeks, 13–25 weeks, 26–37 weeks and 38–40 weeks, with the mean mandibular body length in each group being 11 ± 1 mm, 19 ± 5 mm, 30 ± 7 mm, and 40 ± 3 mm respectively. In all of these groups, no significance difference was seen in the mandibular body length for gender determination.[25] Such studies are extending our findings in the age group of less than 12 years that this index cannot fully distinguish between males and females falling in this age span. Meanwhile, a significant difference in mean values is seen in 12–19 years age group compared to our younger cadavers which is mainly due to the growth of the mandible.

Our study had been conducted on fresh cadavers, thus some degrees of difference from studies on dry bones is anticipated due

to remaining soft tissues despite attempts to remove them from the bone. Also, since our study was performed on fresh cadaver without removing the mandible, measurement of some valuable variables such as ramus length, bicoronoid distance and bicondylar width were impossible.[12,13,19,20] Therefore, future studies on the mandible completely taken out of the cadavers in the Iranian population are recommended.

5. Conclusion

Although the results of our study show that mandibular anthropometric parameters are not helpful in sex determination in samples less than 12 years old, further studies assessing these parameters with larger sample size are recommended.

In scenarios such as explosions, air disasters and other accidents, where only mandible might be available, assessment of symphysial height and especially mandibular bigonial breadth can be helpful in distinguishing genders with a relatively high accuracy (86.2%) in samples older than 12 years of age; even though some researchers[16,26] argue that the skull bones have limited value before puberty.

Our study was performed on fresh Iranian cadavers; therefore, generalizations of our findings to other populations should be done with caution.

Ethical approval

Study protocol approved by Ethics Committee in Research of Tehran University of Medical Sciences.

Funding

Source of funding: Vice Chancellor for Research, Tehran University of Medical Sciences.

Conflict of interest

The authors declared no potential conflict of interest with respect to the authorship and/or publication of this article.

Acknowledgments

This study was part of Dr. Zahra Khalighi's dissertation to get specialized degree in forensic medicine. We are grateful for funding from vice chancellor of research of Tehran University of Medical Sciences. We thank personnel of Dissection hall of Tehran Legal Medicine Organization for their cooperation in the study.

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